

SUBJECT: Communications Performance of
Possible Apollo (LM) USB Downlink
Configurations - Case 320

DATE: December 8, 1969

FROM: N. W. Schroeder

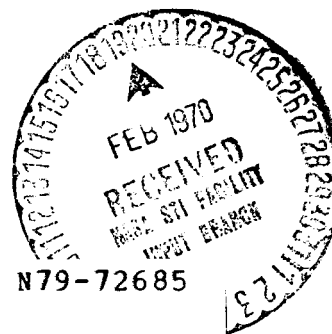
ABSTRACT

Communications Performance predictions are presented for possible configurations of the Apollo (LM) Unified S-Band downlink. This memorandum is the second of two memoranda on this subject. In my last memorandum, worst case parameters were used in the circuit margin calculations; here these predictions are updated by using the parameters published for the Apollo 12 mission.

Using the current Apollo USB communication system parameters, the resulting circuit margins indicate that the most severe constraint on this system is the reception over the frequency modulation (FM) channel of unclipped voice from inside the LM and this constraint is followed closely by the reception of color television from the lunar surface.

The voice constraint is not considered to be a current problem because under present plans, voice that is transmitted over the FM channel is transmitted first over the Extra Vehicular Communications System (EVCS), and the EVCS voice is clipped.

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MEMORANDUM FOR FILE

This memorandum provides a discussion that is intended to update and clarify the results presented in my earlier memorandum titled "Communications Performance of Possible Apollo (LM) USB Downlink Configurations" dated October 23, 1969. This discussion updates the communications performance predictions of Reference 1 in the light of now available Apollo 12 data² and elaborates further on the consequences of the margins calculated for the LM downlink. These later performance data are summarized in Table I.

Television

The television performance discussed in my earlier memorandum is the Apollo 11 type black and white only. Using the threshold data contained in Reference 2, color television performance can be described. The required total received power, stated in Reference 2, for LM color television is -124.0 dBw. Acceptable reception of color television can be expected using the high transmitter power mode of the LM and its erectable antenna in conjunction with a DSN 210' antenna (received signal level -115.3 dBw); marginal reception is expected using the LM steerable antenna and a DSN 210' (received signal level -123.6 dBw) or the LM erectable and an MSFN 85' antenna (received signal level -123.3 dBw).

Voice (FM)

The voice performance of the frequency modulation modes discussed in Reference 1 consist of two types of downlink voice.

1. Voice transmitted when the astronauts are inside the LM and are not using the Extra Vehicular Communications Systems (EVCS). I will refer to this as LM voice.
2. Voice transmitted when the astronauts are inside or outside the LM and are using the EVCS. I will refer to this as EVCS voice.

The most current data available for the required (threshold) total received powers for the LM voice and EVCS voice are -123.0 and -132.0 dBw respectively. The current EVCS voice threshold value is taken from Reference 2, but the current threshold value for LM voice is that given in Reference 1.

So, the reception of LM voice will be acceptable using the high power mode of the LM with an erectable DSN 210' antenna combination, but marginal reception is expected using the LM steerable-DSN 210' and LM erectable MSFN 85' antenna combinations. The reception of the EVCS voice will be acceptable using the high transmitter power mode of the LM in conjunction with either the steerable or erectable antenna and an 85 or 210 foot earth based antenna. EVCS voice performance is expected to be only marginal using the low power mode of the LM with the erectable antenna and a DSN 210' antenna.

Several comments are in order at this point regarding voice transmission from the LM. The difference in the thresholds for the LM voice and EVCS voice lies in the fact that the EVCS voice is clipped (12 dB) prior to transmission, and the LM voice is not clipped. Because of the difference in the peak to rms ratios of unclipped voice and voice that is clipped 12 dB, more signal power (6-8 dB) is required at the input of the receiver to provide intelligible LM voice than EVCS voice. Both services must satisfy the same criteria of 14 dB rms signal to rms noise ratio in the 3 kHz post detection bandwidth.

Although the margin calculations indicate that the LM voice channel is the controlling channel in the LM down-link, the constraint is not as severe as it may appear. In practice, the only time that the LM voice would be transmitted over the FM channel is in the case that television is transmitted while the astronauts are inside the LM. Since the present planning for lunar surface activity includes television transmission only during the Extra Vehicular Activity (EVA) periods, it is not anticipated that the LM voice constraint is currently a problem.

The LM voice constraint is mentioned here and in my earlier memorandum only as information that merits consideration in the event that LM television transmissions are planned in the future during other than EVA periods.

PLSS Status and EVA Biomedical Telemetry

The performance of the biomed channels indicated in Table I of the earlier memorandum is still valid.

Telemetry

The most current data available for the required total received signal powers for LM telemetry when transmitted in an FM mode are the following:

51.2 kbps TLM with TV	-131.6 dBw
51.2 kbps TLM no TV	-133.2 dBw
1.6 kbps TLM with TV	-140.2 dBw
1.6 kbps TLM no TV	-141.8 dBw

The performance of the LM telemetry (FM) channel is expected to be that summarized in Table I.

Summary

The performance predictions presented in my earlier memorandum represent worst case performance and are still valid for use in future mission planning.

The results presented here are intended to clarify and extend the earlier results.

Color television is the most severe constraint on the LM to ground communications link, provided it is transmitted only during lunar surface EVA periods. In the present equipment configuration, if television is to be transmitted on future missions during periods when the extra vehicular communications system is not used, then the LM voice will be the most severe constraint on this downlink.

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Attachment
Table 1

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REFERENCES

1. Schroeder, N. W., "Communications Performance of Possible Apollo (LM) USB Downlink Configurations", October 23, 1969.
2. "Communications Systems Performance and Coverage Analysis for Apollo 12 (H-1 Mission) Mission Summary", MSC Internal Note #MSC-00-173, October 31, 1969.

TABLE I

SUMMARY OF EXPECTED DATA QUALITY USING POSSIBLE APOLLO (LM) USB DOWNLINK CONFIGURATIONST (†)

DOWNLINK SERVICES TRANSMITTED	HIGH POWER (LM TRANSMITTER POWER = 18.6 WATTS)					LOW POWER (LM TRANSMITTER POWER = .345 WATTS)				
	LM ERECTABLE DSN (210')	LM STEERABLE DSN (210')	LM ERECTABLE MSFN (85')	LM STEERABLE MSFN (85')	LM STEERABLE DSN (210')	LM ERECTABLE DSN (210')	LM STEERABLE DSN (210')	LM ERECTABLE MSFN (85')	LM STEERABLE MSFN (85')	LM STEERABLE DSN (210')
FREQUENCY MODULATION MODES										
TV COLOR	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
LM Voice with BIOMED - with TV	+	+	+	+	+	+	+	+	+	+
LM Voice with BIOMED - no TV	+	+	+	+	+	+	+	+	+	+
LM (Dual EVA) EVCS Voice, PLSS status & EVA BIOMED - with TV	+	+	+	+	+	+	+	+	+	+
LM (Dual EVA) EVCS Voice, PLSS status & EVA BIOMED - no TV	+	+	+	+	+	+	+	+	+	+
LM (Single EVA) EVCS Voice, PLSS status & EVA BIOMED - with TV	+	+	+	+	+	+	+	+	+	+
LM (Single EVA) EVCS Voice, PLSS status & EVA BIOMED - no TV	+	+	+	+	+	+	+	+	+	+
51.2 KBPS TLM - with TV	+	+	+	+	+	+	+	+	+	+
51.2 KBPS TLM - no TV	+	+	+	+	+	+	+	+	+	+
TV BLACK and WHITE	+	+	+	+	+	+	+	+	+	+
1.6 KBPS TLM - with TV	+	+	+	+	+	+	+	+	+	+
1.6 KBPS TLM - no TV	+	+	+	+	+	+	+	+	+	+
PHASE MODULATION MODES										
51.2 KBPS TLM - with full PM mode	+	+	+	+	+	+	+	+	+	+
51.2 KBPS TLM - with normal Voice/HL BIOMED	+	+	+	+	+	+	+	+	+	+
LM Voice/HL BIOMED - with full PM mode	+	+	+	+	+	+	+	+	+	+
LM Voice/HL BIOMED - with 51.2 KBPS TLM	+	+	+	+	+	+	+	+	+	+
LM Voice/HL BIOMED - with 1.6 KBPS TLM	+	+	+	+	+	+	+	+	+	+
1.6 KBPS TLM - with LM Voice/HL BIOMED	+	+	+	+	+	+	+	+	+	+
Ranging - with full PM mode	+	+	+	+	+	+	+	+	+	+
1.6 KBPS TLM - with LM B.U. Voice	+	+	+	+	+	+	+	+	+	+
LM B.U. Voice - with 1.6 KBPS TLM	+	+	+	+	+	+	+	+	+	+
1.6 KBPS TLM only	+	+	+	+	+	+	+	+	+	+
LM B.U. Voice only	+	+	+	+	+	+	+	+	+	+
KEY only	+	+	+	+	+	+	+	+	+	+

†Note: Calculations are based on worst case parameters available from Apollo 11 mission

+Power margin is more positive than 1 dB (performance is acceptable)

-Power margin is more negative than -1 dB (performance is not acceptable)

*Power margin is between +1 and -1 dB. (performance is marginal)

(†) Note: () Represents changes from Table I in reference [1]

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